Claims

1. A method for forming and introducing wave windings with straight portions, connected by winding heads, in rotor or stator lamination packets of electrical machines, characterized in that the wave windings (10), each with a defined number of waves, is cut from a continuously formed wave winding band (52) of winding wire (56) of rectangular or round cross section, which wave winding band in the forming operation by a wire guide (54) is laid in alternation around the outer side faces of forming protrusions (50), offset from one another on the circumference of two disks (46, 48), which can be driven to rotate axially side by side, or in two rows on the circumference of a roller that can be driven to rotate, and in the angular range in which the wave winding band (52) is driven on the circumference of the disks (46, 48) or roller respectively, the spacing between one forming protrusion (50) of one row and the next forming protrusion (50) in the other row is increased by such an amount that the outer side faces of the forming protrusions (50) form the winding heads (14) of the wave windings (10), and that the wave windings (10) cut from the wave winding band (52) are introduced into radially outwardly open slots (89) of a rotor or stator lamination packet or a rotorlike transfer tool (88).

2. The method of claim 1, characterized in that in each forming operation, by contact pressure and transverse forces exerted by at least one looping peg (58, 60) mounted eccentrically on a carrier (55) that can be driven to rotate, the winding wire (56) is bent as a first loop around a forming protrusion (50) of one row and as a second loop around the looping peg (58, 60), whereafter the latter loop is stripped off onto a forming protrusion (50) of the other row.

3. The method of claim 1, characterized in that toward the end of the angular range within which the wave winding band (52) is carried along on the circumference of the disks (46, 48) or roller, the tension in the winding wire (56) is reduced again by means of reducing the spacing between the two rows of forming protrusions (50).

4. The method of claim 1, characterized in that at least some of the winding heads (14) of the wave windings (10) are formed in gable-shaped fashion, and then, before they are introduced into the slots of the rod-shaped receiver (22), at least one half of the gable is at least partly forced out of the plane of the traverse portions (12) bordering on the winding heads (14), by plastic deformation.

5. The method of claim 1, characterized in that the wave winding band (52), at least between two forming stations (24, 28) and/or assembly stations, is guided as a loose loop (74), which compensates for different feeding speeds in the two stations (24, 28).

6. The method of claim 1, characterized in that the waves adjoining the intersections of the winding wire (56) are bent open and formed into connection ends (16) of the wave windings (10).

7. The method of claim 1, characterized in that the straight portions (12) of a plurality of wave windings (10) are placed in parallel transverse slots of a rod-shaped receiver (22) and are guided by these slots in the transfer to radially outwardly open slots (89) of a rotor or stator lamination packet or rotorlike transfer tool (88).

8. The method of claim 1, characterized in that the

wave windings (10) are brought essentially tangentially to a rotor or stator lamination packet or a rotorlike transfer tool (88), in each case having radially outwardly open slots (89), and during a rotary motion of the lamination packet or transfer tool (88) and a substantially tangential relative motion, corresponding to the circumferential speed of the rotary motion, of the bandlike wave windings (10), their straight portions (12) are pressed into the slots (89).

9. The method of claim 8, characterized in that after the reception of the wave windings (10), the transfer tool (88) is inserted into the stator lamination packet (20) of a stator or rotor having radially inwardly open slots (18), and the wave windings (10) are positively displaced out of the slots (89) of the transfer tool (88) radially into the slots (18) of the lamination packet (20).

10. The method of claim 8, characterized in that the wave windings (10) are long enough that during multiple revolutions of the rotor or stator lamination packet or the rotorlike transfer tool (88) having radially outwardly open slots (89), they can be introduced into these slots (89).

11. The method of claim 7, characterized in that the wave windings (10) are placed in multiple layers, each in one piece, into the rod-shaped receiver (22).

12. The method of claim 7, characterized in that between two layers of a wave winding (10), at least one layer of a different wave winding (10) is placed in other slots of the rod-shaped receiver (22).

13. The method of claim 7, characterized in that at least one wave of a wave winding (10) placed in the rod-

shaped receiver (22) is bent out of its bandlike plane by approximately 90° and is bent back again after the placement of at least one further wave winding (10) in the rod-shaped receiver (22).

14. The method of claim 9, characterized in that after the introduction of a plurality of wave windings (10) into the lamination packet (20) of a stator or rotor having radially inwardly open slots (18), the winding heads (14) of the wave windings (10) protruding on the face ends from the lamination packet (20) are positively displaced farther outward radially, and then further wave windings (10) are introduced into these slots (18).

15. The method of claim 14, characterized in that the wave windings (10) thrust into the slots (18) of the lamination packet (20) in the first step are formed with wider winding heads (14) than the wave windings (10) introduced in the second step.

16. The method of claim 15, characterized in that the wave windings (10) thrust into the slots (18) of the lamination packet (20) in the second step are formed with taller winding heads (14) than the wave windings (10) introduced in the first step.

17. An apparatus having a forming device for forming a wave winding band (52) and a device for introducing wave windings (10) cut from this band into radially outwardly open slots (89) of a rotor or stator lamination packet or a similar transfer tool (88), characterized in that the forming device (24) for the wave winding band (52) has two rotatable disks (46, 48) or one rotatable roller and two rows of forming protrusions (50) distributed uniformly over the circumference and offset from one another relative to the respectively other row and protruding past the circumference of the disks or

roller respectively, and a wire guide (54) guided in such a way that a winding wire (56) can be placed in undulating fashion in alternation about the outer side faces of the successive forming protrusions (50) on the circumference, whose shape corresponds to the shape to be generated of the winding heads (14) of the wave windings (10).

18. The apparatus of claim 17, characterized in that the free spacing measured at the circumference between one forming protrusion (50) of one row and the next forming protrusion (50) in the other row is equivalent to the thickness of the winding wire (56).

19. The apparatus of claim 17, characterized in that in plan view on the circumference of the disks or roller the side faces, pointing away from one another, of the forming protrusions (50) each have the shape of a gable.

20. The apparatus of claim 17, characterized in that along the circumferential length traversed by a wave winding (10) on the disks (46, 48) or roller the axial spacing between one forming protrusion (50) of one row and the next forming protrusion (50) of the other row can initially be increased and then reduced.

21. The apparatus of claim 20, characterized in that each row of forming protrusions (50) is mounted on a disk (46, 48) that is supported individually in tumbling or oblique fashion such that the spacing between the two rows along the circumferential length traversed by a wave winding (10) is initially increased and then reduced, and as a result of the increase in spacing, the winding wire (56), drawn tautly against the gable-shaped outer faces of the forming protrusions (50), is formable with corresponding gable-shaped winding heads (14).

22. The apparatus of claim 17, characterized in that

- the wire guide (54) is a carrier (55) driven to rotate about an axis of rotation located essentially transversely to the axis of rotation of the disks (46, 48) or roller and having at least one eccentric looping peg (58, 60) and one tappet (64) that can be axially advanced in controlled fashion and is disposed essentially on the axis of rotation,
- the carrier (55) having the looping peg or pegs (58, 60) immediately next to the disks (46, 48) or the roller revolves in chronological adaptation to the rotary motion thereof,
- in a first intermediate phase of a work cycle the tappet (64) can be advanced to the winding wire (56), delivered into the space between the carrier (55) and the disks (46, 48) or roller, and to a forming protrusion (50) of one row, so that the winding wire (56) is retained on this forming protrusion (50) to form a first loop,
- and that in a second intermediate phase, in which a forming protrusion (50) of the other row is located axially in front of a looping peg (58, 60), a stripper (72) can be actuated, by which a second loop formed from the winding wire (56) on the looping peg (58, 60) can be stripped from the looping peg (58, 60) onto the forming protrusion (50) located in front of it.

23. The apparatus of claim 22, characterized in that the carrier (55) revolves in the direction of rotation in which the looping peg (58, 60), moved with its circumferential surface against the winding wire (56), forms the first loop around a forming protrusion (50) of one row and simultaneously forms the second loop around itself.

24. The apparatus of claim 22, characterized in that the carrier (55) of the at least one driver peg (58,

60) revolves discontinuously, for instance being driven by a Maltese-cross drive mechanism.

25. The apparatus of claim 22, characterized in that for varying the height of the wave windings (10) to suit different lamination packet heights, the maximum axial spacing between the two rows of forming protrusions (50) and the eccentricity of the driver peg or pegs (58, 60) on the carrier (55) are variably adjustable.

26. The apparatus of claim 17, characterized in that a stamping device (28) is disposed between the forming device (24) and a loading station (30) for placing the wave windings (10) in rod-shaped receivers (22), which stamping device has a conveyor means (76) adapted to the wave winding (10), such as an endlessly revolving conveyor belt that can be controlled with precise positioning, with drivers (78) mounted on the outside at the spacing of the straight portions (12), and also has one or more male dies (82) and female dies (84) laterally beside the conveyor belt (76), by which dies at least part of one winding head (14) of a wave winding (10) to be placed in the receiver (22) can be forced out of the plane of the adjacent straight portions (12).

27. The apparatus of claim 26, characterized in that the stamping device (28) has cutting tools for cutting the wave windings (10) to the proper length from the wave winding band (52).

28. The apparatus of claim 26, characterized in that between the forming device (24) and the stamping device (28) there is a loose guide (80) for the formed wave winding band (52), so that by means of this band a loop (74) of variable length serving as a buffer store can be formed.

29. The apparatus of claim 17, characterized in that the device for introducing the wave windings into a rotor or stator lamination packet or rotorlike transfer tool (88) has

- a guide (22) for the wave windings (10) which is disposed essentially tangentially relative to a rotor or stator lamination packet or rotorlike transfer tool (88), each having radially outwardly open slots (89), that can be driven to rotate by a rotary mechanism,
- a drive for relative advancement of the bandlike wave windings (10) with their straight portions (12) joined by winding heads (14) and/or of the lamination packet or transfer tool (88) along the guide (24) at a speed corresponding to the circumferential speed of the lamination packet or transfer tool (88)
- and guide or thrust devices (90, 92) by which the straight portions (12), brought to the lamination packet or transfer tool (88), of the wave windings (10) can be introduced in succession into the radially outwardly open slots (89).

30. The apparatus of claim 29, characterized in that the guide has a longitudinally movable rod-shaped receiver (22) with parallel transverse slots, into which a plurality of wave windings (10), to be introduced jointly into the lamination packet or transfer tool (88) in one work step, can be placed with their straight portions (12) in the predetermined relative position.

31. The apparatus of claim 30, characterized by stationary guide devices (90, 92), engaging the outer regions of the straight portions (12) and/or the winding heads (14) of the wave windings (10), by which guide devices the straight portions can be positively displaced into the radially outwardly open slots (89) of the lamination packet or transfer tool (88) while the lamination packet or transfer tool rotates about a

stationary axis and in the process rolls along the rod-shaped receiver (22) that is moved past it at a tangent, or along a line parallel to it.

32. The apparatus of claim 31, characterized in that the rotorlike transfer tool (88) in the radially outwardly open slots (89) has radially displaceably guided slides (94) which can be moved to beyond the outer circumference and by which wave windings (10) received in the slots (89) can be positively displaced into aligned, radially inwardly open slots (18) of a rotor or stator lamination packet (20) disposed concentrically to the transfer.

33. The apparatus of claim 32, characterized in that the axially fixed slides (94) are provided with wedge-shaped faces and are movable radially by means of corresponding wedge-shaped or conical faces (98) of a common, axially movable drive member (96).

34. The apparatus of claim 26, characterized in that the loading station (30) for placing the wave windings (10) in rod-shaped receivers (22) has

- movably supported guide rails (86) extending parallel to one another and to the receiver (22) and extending in projection at the sides of the receiver, which rails guide the winding heads (14) of the wave windings (10),
- an endlessly revolvingly guided conveyor belt (76), which can be controlled with precise positioning, with drivers (78) provided on its outside with the same spacing as the straight portions (12)
- and a positioning drive mechanism for moving the guide rails out of a position in front of the slot entrances in the rod-shaped receiver (22) into a position at the sides of these entrances, whereby the straight portions (12) of the wave windings (10) are introduced into the slots of the receiver (22).

35. A method for forming and introducing wave windings with straight portions, joined by winding heads, into rotor or stator lamination packets of electrical machines, characterized in that the wave windings (10) are each formed with a defined number of waves as a wave winding band of winding wire (56) of rectangular or round cross section, in that the wire from a wire guide (54) is laid in alternation around the outer side faces of forming protrusions (50) offset from one another on two rods, drivable side by side linearly in the longitudinal direction, or in two rows on one rod that is drivable linearly in the longitudinal direction.

36. An apparatus for performing the method of claim 35, having a forming device for forming wave windings and a device for introducing the wave windings (10) into radially outwardly open slots (89) of a rotor or stator lamination packet or of a rotorlike transfer tool (88), characterized in that the forming device (24) for the wave windings (10) has two rods, disposed side by side and displaceably linearly in the longitudinal direction, or one rod and on it two rows of protruding forming protrusions (50), distributed uniformly relative to the respectively other row and offset from one another, and one wire guide (54) guided in such a way that a winding wire (56) can be placed in undulating fashion in alternation about the outer side faces of the forming protrusions (50) in the two rows succeeding one another on the circumference, whose shape corresponds to the shape to be generated of the winding heads (14) of the wave windings (10).